STUDIES OF JUNIPER RUSTS IN THE WEST

Roger S. Peterson

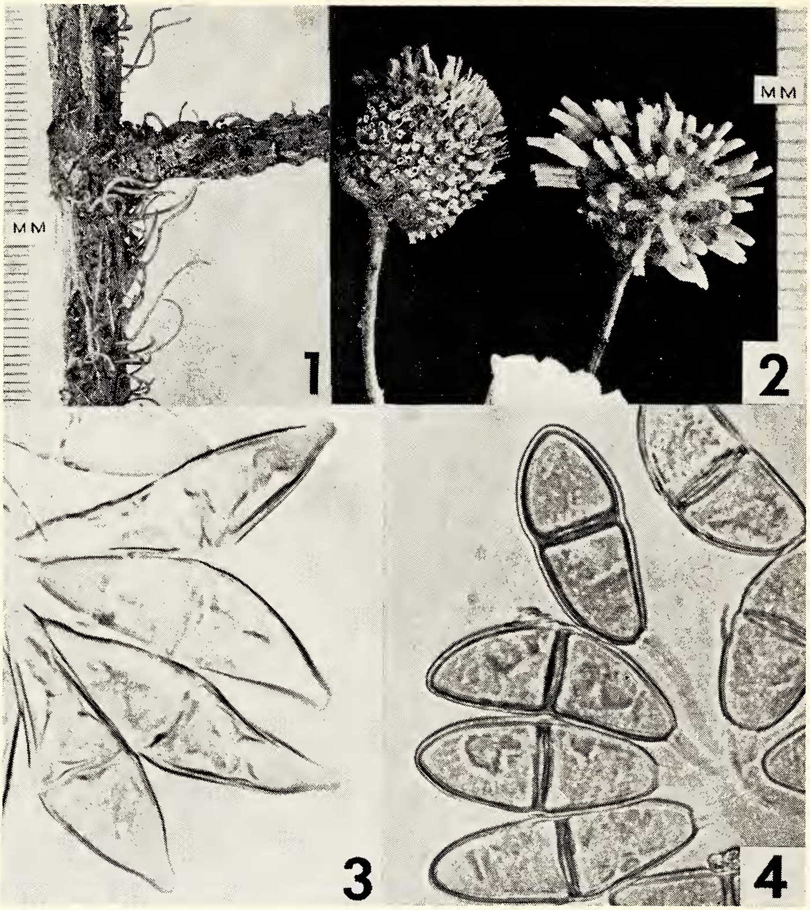
Included here are a review of *Gymnosporangium* species that occur in the Great Basin and a description of a new species of rust fungus on *Juniperus deppeana* in the Southwest. No taxonomic changes are proposed for the 11 species known in the Great Basin (which includes most of Nevada, half of Utah, and parts of California and other adjacent States), but amendments to published descriptions are pointed out, new data on ecology, hosts, and distribution are given, and the life cycle of *G. kernianum* is established on the basis of inoculations. One species that does not infect juniper, *G. libocedri,* is included to complete the roster of *Gymnosporangium* for the Great Basin.

Hyphenated numbers are those of the author's collections, the first digits representing the year. Specimens are housed in the Forest Service herbarium at Logan, Utah, and in the National Fungus Collections at Beltsville, Maryland.

Gymnosporangium in the Great Basin

Previous keys to telial stages have included as primary criteria some—but not all—of the symptoms caused by these fungi, and only some of the host organs on which telia are found. As a result, many specimens could not be reached in the keys. The following artificial key emphasizes fungus morphology, with some attention to host range where this is constant. Descriptions of shapes apply to telia before they gelatinize.

Many teliospores with 1 or 3 cells.
  Telia round; brown or red-brown.
    Apical germ pore usually present; on *Heyderia* . . . . *G. libocedri*
    Apical germ pores lacking; on *Juniperus* . . . . *G. kernianum*
  Telia elongate; orange . . . . *G. speciosum*
Teliospores with other than 2 cells rare or lacking.
  Many teliospore germ pores apical or scattered.
    Germ pores several per cell, scattered . . . . *G. multiporum*
    Germ pores 1 or 2 per cell, near crosswall or apical.
      Telia more than 2 mm diameter; on *J.* sect. *Juniperus* . . . *G. tremelloides*
      Telia less than 2 mm diameter; on *J.* sect. *Sabina.*
        Most pedicel-tops swelling greatly in water . . . . . . *G. inconspicuum*
        Pedicels remaining cylindric in water . . . . *G. nidus-avis*
  Nearly all teliospore germ pores near crosswalls.
    Telia mostly broader than high: hemispherical or indefinite mounds.
      Teliospores 12–26 × 39–61μ; a few pores apical . . . . . . *G. nidus-avis*
      Teliospores 20–30 × 41–80μ; no apical pores . . . . . . *G. kernianum*
    Telia higher than broad; cylindric, conic, frustum- or tongue-shaped.
      Telia cylindric or club-shaped, tan to yellow-orange . . . *G. clavariiforme*
      Telia tapering upward; chestnut- to chocolate-brown.
        Telia less than 2 mm high; not on galls.
          Spore tips often protuberant; pores not papillate . . *G. harknessianum*
          Spore tips seldom protuberant; pores usually papillate . . *G. kernianum*
        Telia often more than 2 mm high; usually on galls.
          Average length brown-wall spores less than 50μ . . . . . *G. bethelii*
          Average length brown-wall spores more than 50μ . . . . *G. nelsonii*



FIGS. 1–4. 1, Aecia of *Gymnosporangium harknessianum* on *Amelanchier;* 2, aecia of *G. kernianum* (left) and *G. inconspicuum* (right) in the same collection on *Amelanchier utahensis;* 3, teliospores of *G. harknessianum* from *Juniperus occidentalis,* × 515; 4, teliospores of *G. kernianum* from *Juniperus osteosperma,* × 515.

Discussion that expands upon treatments by Arthur (1934) or Kern (1911, 1964), rather than repetitive description, follows for the above species, alphabetically arranged. New western records from outside the Great Basin are listed in separate paragraphs.

GYMNOSPORANGIUM BETHELII Kern. Rhoads' discussion (1946) supplements previous inadequate descriptions of symptoms. *Gymnosporangium bethelii* is abundant on *Juniperus scopulorum* and *Crataegus rivularis* in the parts of Utah, Idaho, and Wyomng that are in the Great Basin. *C. rivularis* in the Basin is almost restricted to riverbanks and moist canyons, and the rust is similarly restricted. *Gymnosporangium* *bethelii* has not been collected in Nevada, where *Crataegus* may be restricted to part of Elko Co. (McVaugh, 1942), and occurs mostly at lower elevations than *J. scopulorum.*

Gymnosporangium bethelii has not previously been reported from Arizona but is common there on *J. scopulorum* in Oak Creek Canyon, Coconino Co. *(66–37).*

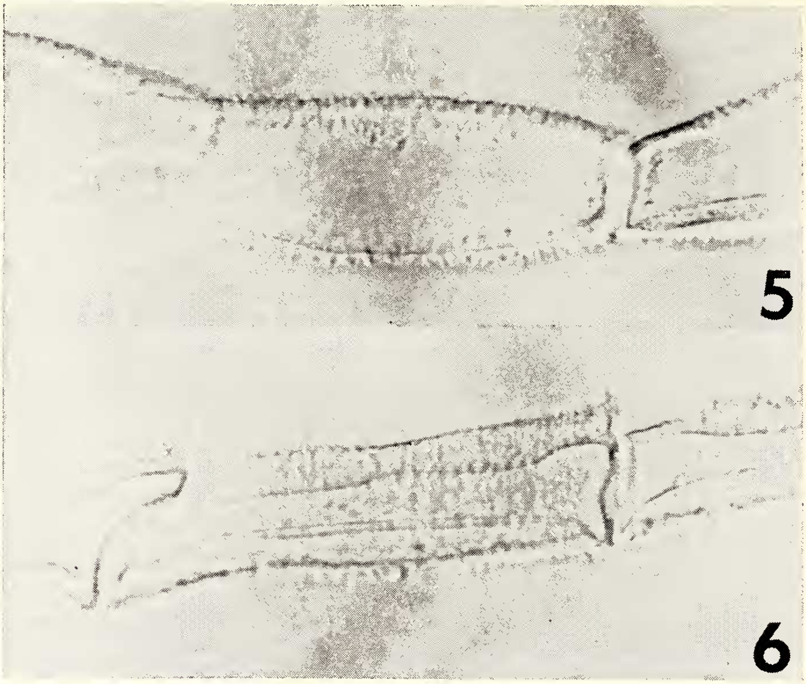
The key characteristic given above to separate *G. bethelii* from *G. nelnelsonii* may not prove satisfactory when more collections are examined, but on account of their distinct aecial states the two fungi should be maintained as separate. The matter is discussed further under *G. nelsonii,* below. I did not study whether *G. bethelii* is distinct at the species level from eastern *G. globosum* Farl., which is somewhat similar in all spore stages.

GYMNOSPORANGIUM CLAVARIIFORME (Pers.) DC. Krebill (1967) showed variations in morphology and effects of this species, which can cause witches'-brooms as well as woody swellings on juniper. *Gymnosporangium clavariiforme* is not abundant in the Great Basin, but Krebill found that it is occasional on *Juniperus communis* in Utah, and he has collected it on that host just outside the Great Basin in western Wyoming and southeastern Idaho. It also appears to be only occasional—or at least rarely collected—on *Amelanchier alnifolia* and *A. utahensis* in Utah. It is not yet recorded from the western half of the Basin.

Gymnosporangium clavariiforme occurs in Oregon on *Crataegus columbiana* (63–232 from North Burnt River, Baker Co.) and has previously been recorded in the other Pacific Coast States.

Aeciospores of this species are often larger than recorded in American descriptions. Sixty spores from a collection obtained from artificial infection on *A. alnifolia (R. G. Krebill 388)* measured 23–30 $\times$ 28–37μ with an average of 27 $\times$ 32μ. A collection on *A. utahensis* from northern Utah *(Krebill 186)* averaged 26 $\times$ 33μ, with a few spores as large as 33 $\times$ 42μ. Specimens in which the aecia remain firm and finally dehisce apically are common but cannot be reached in present keys.

GYMNOSPORANGIUM HARKNESSIANUM Kern ex Arth. This species has not previously been recorded from the Great Basin. It occurs there not only in the eastern Sierra Nevada on the known telial host, *Juniperus occidentalis (63–174* from Fallen Leaf Lake, Eldorado Co., California, and *W. W. Wagener F. P. 97510* from Cascade Creek in Alpine Co., California) but also in the hills of western Nevada on new hosts: *J. osteosperma* and *Amelanchier utahensis (65–131* and *65–132* from Flowery Ridge, Storey Co.). The latter collections were within two meters of one another. The occurrence of this fungus in relatively dry pinyon-juniper woodland establishes a newly recorded ecologic habitat as well as a new State and host record. In *A. utahensis* the fungus is perennial and causes cankers up to 30 cm long. Aecia range up to 15 mm high (fig. 1), exceeding those of any other species in the Great Basin and exceeding previous measurements for *G. harknessianaum.*



FIGS. 5–6. Peridial cell of *Gymnosporangium kernianum:* 5, in face view, × 600; 6, in side view, × 600. The concave, smooth outside wall appears to be within the cell.

Aeciospores in a 100-spore sample averaged 25 × 30μ, and their range of dimensions, 20–29 × 24–37μ, is much greater than previously recorded. However, similar dimensions are present in my collections on *A. pallida* from California and Oregon, so the large size is not an effect of *A. utahensis*. A parallel situation exists for teliospores: on *J. osteosperma* the largest seen were 23 × 96μ, to be compared with the 22 × 72μ maxima given for *G. harknessianum* by Arthur (1934). However, three collections on *J. occidentalis* all contained teliospores as long as 87μ, with a maximum of 98μ in *F. P. 97510* (cited above). The tendency of this species to have part of the teliospore wall concave (fig. 3) distinguishes it from some related species, for instance *G. kernianum* (fig. 4).

GYMNOSPORANGIUM INCONSPICUUM Kern. This is by far the most abundant *Gymnosporangium* on juniper and one of the most abundant species on *Amelanchier* in the Great Basin. McVaugh (1942) wrote that ". . . in some areas . . . of the Great Basin the *Amelanchier* fruits may be so heavily infested that it is almost impossible to find one maturing normally; the infected fruits are often colored bright yellow or orange by the rust, so that whole bushes may appear at first glance to bear yellow or orange fruit." It is almost entirely *G. inconspicuum* that causes these color effects; other species are much less common on fruits in the Basin and are much less bright in color.

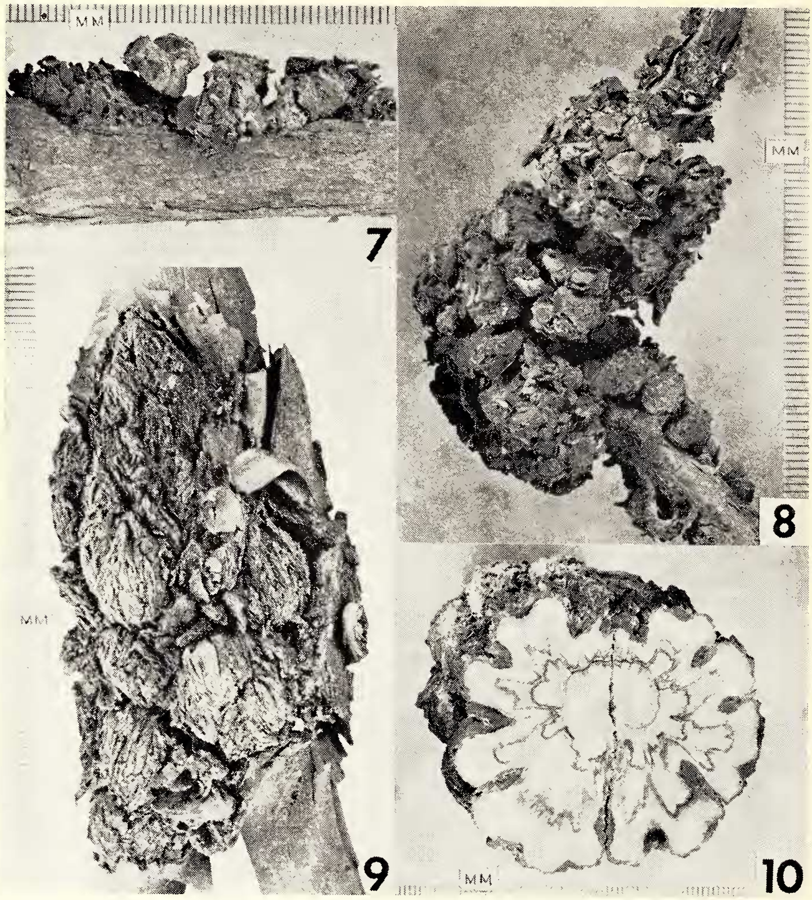
Telia can be found in almost any stand of *J. osteosperma* throughout the millions of acres of this species in Utah and Nevada. *G. inconspicuum* is as common on older branches and larger stems as on the green twigs from which it has been reported before. Swelling of host tissue is slight or lacking in most stem infections, but the bark becomes abnormally rough. Although telia usually fall off green twigs after gelatinization, leaving no obvious sign of infection, on woody bark they are often retained in the cracks so that the disease can be diagnosed at any time of year. Sometimes telia are associated with ill-defined witches'-brooms on *J. osteosperma,* but no systemic mycelium was found and a causal relation was not established. The fungus does cause woody swellings, but only rarely.

Gymnosporangium inconspicuum is newly recorded from Nevada (many collections, including *63–333* on *A. utahensis* and *63–334* on *J. osteosperma* from the Grant Range, Nye Co.); Idaho *(66–11* on *J. osteosperma* from the Bear River Range, Franklin Co.); and Wyoming *(66–7* on *J. osteosperma* from the Crawford Mountains, Lincoln Co.).

Outside the Great Basin, newly recorded hosts of *G. inconspicuum* are *J. deppeana (65–55* from the Chiricahua Mountains, Cochise Co., Arizona, and *66–36* from Oak Creek Canyon, Coconino Co., Arizona) and *J. monosperma (65–58* from Bear Mountain, Grant Co., New Mexico, and *66–41* from Showlow, Navajo Co., Arizona). On *J. monosperma* the fungus appears to cause release of a few dormant buds but no well-developed witches'-brooms. On *J. deppeana* the telia collected were on woody twigs and, in one instance, on a large gall caused by *G. speciosum. Gymnosporangium inconspicuum* is also common on *J. osteosperma* in the Southwest (*61–44* and *66–31* from the Kaibab Plateau, Coconino Co., Arizona) and is often the only *Gymnosporangium* to be seen on this host under arid conditions, for instance in Petrified Forest National Park.

Although later manuals list only *J. osteosperma* as telial host of *G. inconspicuum* and have Arizona and Utah as its western limits, Blasdale (1919) recorded the species on *J. occidentalis* from Big Bear Valley in San Bernardino Co., California. Two of E. Bethel's collections on which Blasdale's record was based appear to me to have been correctly identified as *G. inconspicuum.*

Gymnosporangium kernianum Bethel. This fungus is locally common on *J. osteosperma* and occurs on *Amelanchier utahensis* virtually throughout the Great Basin. Unlike *G. inconspicuum* and *G. nelsonii,* however, it is absent from many stands where these alternate hosts occur together. It was found in Wyoming *(66–5* on *J. osteosperma* from the Crawford Mountains, Lincoln Co.) in addition to States previously recorded.



FIGS. 7–10. 7–8, Galls caused by *Gymnosporangium nelsoni* on *Juniperus* sp. near Zitácuaro, Michoacán; 9, galls caused by *G. speciosum* on *Juniperus deppeana* in the Chiricahua Mountains, Arizona; 10, cross-section of a *G. speciosum* gall like that in fig. 9.

Arthur's description (1934) of the aecia on *Amelanchier* was based on a wrong concept of the species, so Kern (1964) omitted *Amelanchier* as a host and substituted a corrected concept based on specimens on *Pyrus, Cydonia,* and *Crataegus.* However, in many of the Great Basin mountain ranges where *G. kernianum* is common, *Amelanchier* is the only one of these rosaceous genera present. Scores of collections of rust fungi on *A. utahensis* were examined; one (*65–466* from the Pequop Mountains, Elko Co., Nevada) was found to include *G. kernianum.* The aecia on *Amelanchier* fruits are inconspicuous among the larger, brighter, and more abundant aecia of *G. inconspicuum* (fig. 2).

Previous inoculations to establish the life cycle of *G. kernianum* resulted in the production of spermogonia but not aecia on *Amelanchier* (Arthur, 1934). Production of aecia would have averted the 30-year misunderstanding of the species. Because Kern's new description of the aecia, too, was not confirmed by inoculation results, on 12 May 1966, I inoculated two shoots of a potted *Amelanchier alnifolia* in the greenhouse by suspending over them telia on *J. osteosperma* (*66–4* from Rich Co., Utah). Abundant spermogonia appeared on leaves (both surfaces) on 19 May and continued to be produced for several weeks on the inoculated shoots. Other equally succulent shoots on the same plant remained free of infection, as did inoculated seedlings of *Malus sylvestris* cv. Red Delicious and cv. Winesap. Aecial initials were first observed on *Amelanchier* on 6 June but no aecia were mature until 20 June. Between then and 12 July when the leaves were harvested *(66–16)*, about 50 aecia were produced from about 10 infections, and most of them began to dehisce; scores of other infections did not go beyond the spermogonial stage in spite of attempts to crossfertilize them. Aecia were mostly on lower leaf surfaces.

Aecia of this "pedigreed" specimen are roestelioid and 1–3 mm high. Peridial cells vary from linear rhomboidal to (mostly) boat shaped: the outer surface is concave, forming the interior of the "boat," and the sides curve inward to the rounded "bottom" (figs. 5, 6). Peridial cells from halfway up an aecium are 24–33 $\times$ 61–110μ in face view and 24–41μ thick. Inner and side walls are moderately verrucose for the most part, but there are usually some cylindrical tubercles 3 or 4μ high, especially near the "gunwales." Sidewalls are about 4μ thick and inner walls are 4–13μ thick. Outer walls are smooth and usually about 1.5μ thick, or occasionally as much as 3μ. Aeciospores in a 50-spore sample measured 22–28 $\times$ 23–33μ with an average of 25 $\times$ 28μ. Aeciospore walls are yellow-brown, 1.5–2.5μ thick and finely verrucose; they bear six to nine conspicuous germ pores.

Although the cultured aecia did not seem to contain any very long peridial cells, I have no doubt that they represent the same taxon in which cells more than 200μ long were found (Peterson, 1963). Although mature, the greenhouse-grown aecia as well as peridial cells are smaller than in natural collections. Perhaps *Amelanchier* leaves are an unfavorable substrate for the fungus in comparison with fruits of this or other genera.

Telia of *G. kernianum* have been described as caulicolous (Arthur, 1934). Microtome sections of telia in four specimens showed them to be of subhypodermal origin on leaves rather than on stems. Mycelium occurs throughout both leaves and stems.

Gymnosporangium kernianum is much more widely distributed than Arthur (1934) recorded. Cummins (1964) found it in Texas. It is also on *J. californica* in California *(65–35* near Jacumba, San Diego Co., and *R. G. Krebill 249* from Phelan, San Bernardino Co.) and in Baja

California *(65–27* from the western foothills of the Sierra San Pedro Mártir)—a first record from Mexico. In Arizona it infects *J. osteosperma (62–137* from the South Rim, Grand Canyon National Park) as well as *J. deppeana.*

On *J. californica,* a newly recorded host species, some teliospore walls are much thicker than previously recorded for *G. kernianum,* as much as 3μ or rarely 5μ thick including the occasional apical ornamentation. Most spores, however, have smooth walls $0.8–1.5\mu$ thick as on other Junipers.

GYMNOSPORANGIUM LIBOCEDRI (P. Henn.) Kern. This species with telia on *Heyderia decurrens* and aecia on *Amelanchier* and other genera is the only *Gymnosporangium* in the Great Basin that does not inhabit juniper. It is abundant on *Heyderia* in the Sierra Nevada, including the western Nevada portion of this mountain range. The common, conspicuous witches'-brooms caused by this fungus represent only a minute percentage of infections, most of which do not become systemic.

This species is surely the most abundant *Gymnosporangium* in northern California, at least in recent years. It is surprising that it is quite uncommon south of Yosemite National Park, and I could find none of it on *Heyderia* in Baja California.

GYMNOSPORANGIUM MULTIPORUM Kern. This seldom-collected species is the only *Gymnosporangium* of unknown life cycle in the Great Basin. It occurs on *Juniperus occidentalis* in Eldorado Co., California, but has not yet been found in typical Great Basin habitats.

Kern and Keener (1960) hypothesized that *Peridermium ephedrae* is the aecial state of *G. multiporum.* My inoculations with *P. ephedrae* aeciospores, which were kindly supplied by Professor Keener, failed to produce infection on *J. osteosperma, J. virginiana,* or *Ephedra viridis.* I do not believe that any *Ephedra* grows near Fallen Leaf Lake, where *G. multiporum* was collected in Eldorado Co.

GYMNOSPORANGIUM NELSONII Arth. This species is occasional to abundant throughout the Great Basin, and is the only *Gymnosporangium* known on both principal junipers of the area, *J. osteosperma* and *J. scopulorum.* It is also abundant in some years on *Amelanchier alnifolia, A. utahensis,* and, very locally, on *Peraphyllum ramosissimum* in the Basin.

Gymnosporangium nelsonii infects *J. californica* in the vicinity of Jacumba, San Diego Co., California—both a new host and a new State for the fungus *(65–34).*

Gymnosporangium nelsonii and *G. bethelii* are very similar in the telial state. In my collections the overall size ranges for teliospores are $17–28 \times 41–74\mu$ in *G. nelsonii* $15–26 \times 32–65\mu$ in *G. bethelii.* However, many *G. nelsonii* collections lack distinctively long spores. Intersextile lengths (the sixth largest and sixth smallest omitted) of spores with colored walls are more helpful: $50–59\mu$ in *G. nelsonii* and $46–53\mu$ in *G. bethelii.* Spores with walls that are hyaline or nearly so are present in most collections; in *G. bethelii* they average longer than spores with definitely brown walls. Teliospores of *G. nelsonii* tend to have narrower ends than the rounded spores of *G. bethelii*. Usually the two can be distinguished because *G. nelsonii* in the Great Basin produces a single, subglobose gall from each infection whereas *G. bethelii* produces a canker and a series of irregular galls. But these symptoms intergrade and in any event are useless for identification of young infections.

Specimens tentatively identified as *G. nelsonii* were collected from *Juniperus flaccida* in the State of San Luis Potosí, Mexico (*63–46*, from Barranca de los Mármoles) and on *Juniperus* sp., sect. *Sabina*, in the state of Michoacán (63–46, from near Zitácuaro). These specimens, and also those from Michoacán and Texas mentioned by Cummins (1964) and one on *J. deppeana* from Hidalgo illustrated by Martínez (1963), display symptoms unlike any described for *G. nelsonii*. The cankers with their series of lobed, stalked galls from a single infection (figs. 7, 8) resemble those of *G. bethelli* more than typical infections of *G. nelsonii*. The teliospores, however, are longer even than typical *G. nelsonii* and quite unlike *G. bethelii*.

Another doubtful assignment to *G. nelsonii* is collection *64–187* on leaves of *Amelanchier utahensis* from a near-desert woodland east of Escalante, Utah. Aeciospore walls are unusually dark chocolate brown, perhaps an example of desert melanism. Aeciospore dimensions in a 50-spore sample are 23–33 $\times$ 27–37μ with an average of 27 $\times$ 32μ—larger than previously described for *G. nelsonii* or indeed, for any rust fungus on *Amelanchier* leaves except *G. clavariiforme* as it is described above. Peridial cells were like those of *G. nelsonii*, and galls of this species as well as *G. inconspicuum* infections were nearby on *J. osteosperma*.

GYMNOSPORANGIUM NIDUS-AVIS Thaxter. This species is locally common to abundant on *J. scopulorum* and *Amelanchier* spp. in the three eastern States of the Great Basin—Wyoming, Idaho, and Utah. I have not yet seen specimens from Nevada.

Gymnosporangium nidus-avis causes witches'-brooms on *J. scopulorum* similar to those of *G. kernianum* on *J. osteosperma;* also, the spore descriptions of the two species overlap to a confusing extent. Nevertheless, they are distinct fungi. Probably in all telial collections of *G. nidus-avis* a substantial number of spores have apical germ pores, which is not true of *G. kernianum*. Also they are host specific—even where *J. scopulorum* and *J. osteosperma* are closely mingled it is common to see one of them heavily infected by its own peculiar broom-rust parasite, whereas the other juniper is free of rust.

GYMNOSPORANGIUM SPECIOSUM Peck. This species is locally common on *J. osteosperma* and *Philadelphus* in southern and eastern Utah. Its symptoms on *J. osteosperma* include witches'-brooms as well as fusiform galls (Rhoads, 1946). Sometimes whole trees appear to be infected, with telia in small patches scattered over the rough-barked trunks and branches.

Swellings caused by *G. speciosum* are described as "gradually fusiform" (Kern, 1964). The distinctive galls that it causes on *J. deppeana* (figs. 9, 10) are often rather abrupt, and large ones are 35 cm or more in diameter, some of them almost spherical. Others are elongate and may resemble those on *J. mexicana,* illustrated by Cummins (1943).

Although most witches'-brooms on *J. deppeana* are caused by *G. kernianum,* in the Santa Rita Mountains of southern Arizona I observed on this host occasional brooms associated with long-fusiform swellings caused by *G. speciosum.*

A New Species of Rust Fungus on Juniperus

Uredo apacheca R. Peterson, sp. nov. Urediniis forma irregulari, exiguis vel usque ad 3 × 10 mm, plerumque occultatis sub cortice, albidis vel pallide flavidis; peridio crassitudine cellula unica, fragile; cellulis peridii oblongis, plerumque 24–35 × 35–45μ, ca. 15–20μ cr., membrana verrucosa; urediniosporis in catenis, ellipsoideis vel piriformibus, 16–33 × 25–54μ, plerumque 21–26 × 27–33 μ, membrana inaequabiliter (1.0–) 1.5–2.0 (–3.5)μ cr., verruculosa; poris germinationis non visis. In caulibus Juniperi deppeanae, tumores fusiformes faciens.

Specimens examined, all collected by the author in the San Francisco Mountains in Catron Co., New Mexico: *66–50* (BPI-holotype), Gila National Forest about 8 road-miles south of Luna along U.S. Highway 180, Sec. 31, T. 6 S. R. 20W; *65–60,* same place as the preceding; *66–51,* Apache National Forest, Blue River-Brushy Mountain road, Sec. 7 or 8, T. 8 S. R. 21 W.

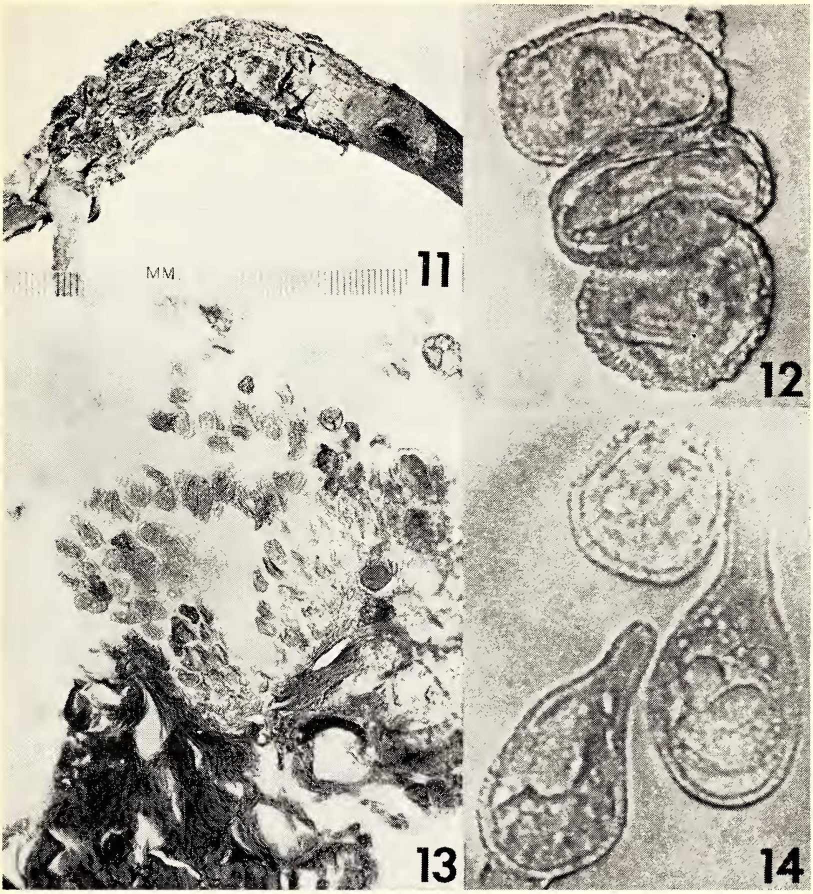
The specific epithet honors a major ethnic group of the area.

Uredo apacheca causes conspicuous, fusiform galls on alligator juniper. Old galls become very rough-surfaced, like those described above for *Gymnosporangium speciosum* on the same host.

Uredo apacheca was not abundant in either locality where it was studied. One or two trees were heavily infected in each area and resembled the juniper pictured by Cummins (1943) that was infected by *G. ?speciosum.* Other trees in each locality bore only one or two galls. No young infections could be found: the youngest one (fig. 11) is at least 10 years old. The clustering of galls in the heavily infected trees suggests direct juniper-to-juniper transmission of the fungus.

Woody vegetation in both collection localities consisted largely of *Pinus edulis, Juniperus deppeana, Quercus gambelii,* and *Cercocarpus montanus.* No Pomoideae—the usual aecial hosts of rust fungi on *Juniperus*—were seen.

Uredo apacheca is the fifth described fungus with uredinia on Cupressaceae and the first on *Juniperus* sect. *Sabina,* the others being on *J.* sect. *Juniperus, Chamaecyparis, Heyderia,* and *Cupressus* (Kern, 1964; Peterson, 1967). It is the first species on Cupressaceae reported to have uredinia with peridia or urediniospores borne in chains (figs.



FIGS. 11–14. 11, Gall caused by *Uredo apacheca* on *Juniperus deppeana;* 12, peridial cells of *U. apacheca,* × 700; 13, a small uredinium and spores of *U. apacheca,* × 140, overlying bark was cut away in preparing the section; 14, pyriform spores of *U. apacheca,* × 720.

12, 13). Its urediniospores (fig. 14) scarcely resemble those of any of the other four species. *Uredo apacheca* is more similar to another fungus on Cupressaceae, the Japanese species *Caeoma deformans* (Berk. & Br.) Tub. Host reactions to the two differ, but general morphology—large, irregularly shaped spores borne in chains under a weak peridium—are similar. Of all the rust fungi on Cupressaceae, only *U. apacheca, C. deformans,* and *C. espinosae* Syd. have light-colored spores that lack obvious germ pores. The biggest difference between *U. apacheca* and *C. deformans* is that the latter regularly produces spermogonia and is regarded as an aecial state.

There was a possibility that the sori of *U. apacheca,* too, might be aecia rather than uredinia, although no spermogonia could be found in the infections. Nuclear constitution of the sorus initials and of the mycelium which produces them provides the critical means of distinguishing the two spore stages. Sections of collection 65–60 were cut at 15μ in paraffin and stained by Heidenhain's iron alum-haematoxylon technique. Most rust hyphae in the vicinity of the sori and elsewhere were entirely composed of binucleate cells. In hyphae where apparently uninucleate cells were seen there were also binucleate cells, suggesting that the uninucleate appearance was due to artifacts of sectioning and staining. As the mycelium appeared to be dikaryotic, and there were no spermogonia, it was concluded that the sori are uredinia.

The same tissue sections showed that most urediniospores are binucleate, with a minority of trinucleate spores, a few quadrinucleate ones, and possibly a few uninucleate ones.

The same sections plus others from the same specimen, stained in safranin, showed that the hymenium and underlying mass of fungus tissue totaled only 40–90μ thick except for occasional "pockets" between host cells—these are up to 160μ thick. Some basal cells appeared to produce more than one chain of urediniospores by lateral budding or branching. Mycelium of the fungus is intercellular throughout the host cortex and in much of the phloem, rarely reaching the cambium, and in the one specimen sectioned mycelium was never observed in the xylem. Hyphae are thick—often as much as 7μ—and somewhat contorted, therein resembling some species of *Gymnosporangium.* Haustoria are simple, thick, and usually obovoid.

Individual chains of urediniospores in some instances exceeded 50 spores in length. Narrow ends of pyriform spores and "handles" on occasional other spores pointed toward the hymenium, unlike the arrangement in some other species, as *Cronartium comandrae* Pk., with pointed spores. No clear intercalary cells were seen, but thin-walled fungus tissue in the uredinium probably represented intercalary material. The spore mass was usually covered by host bark, with only narrow openings through cracks.

Coloration, a distinctive characteristic for most rust fungi on Cupressaceae, is a puzzling feature in *U. apacheca.* Most sori appear to be nearly white, but some are yellowish. Both walls and protoplasts of most spores are hyaline, but there are carotenoid pigments in the protoplasm of some. Spore mounts from the sori that are deepest yellow reveal a different sort of coloration: spore walls and probably spore contents are of a uniform, dingy yellow that seems unlike carotenoid pigment. I did not determine whether this color was native to the fungus or the result of leaching of tannins from the host bark.

Germination of spores from collection *66–50* was tested on 2% water agar. Germ tubes were mostly 100–150μ long after 24 hours at 18° C. Tubes were 3–4μ wide and were unbranched or had a few short branches near their bases. It happened that only colorless spores were included in the test, and their tubes were also colorless.

On the surface of collection *65–60* were a few scattered teliospores that probably belong to a *Gymnosporangium*. None could be found clearly associated with the uredinia, which are therefore described in *Uredo,* with the hope that this description will stimulate more thorough study of the life cycle of this remarkable fungus.

Intermountain Forest and Range Experiment Station
Forest Service, U.S. Department of Agriculture, Logan, Utah
Present address: St. John's College, Santa Fe, New Mexico

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NOTES AND NEWS

Steens Mountain.—A paper entitled, 'A botanical excursion to Steens Mountain, SE Oregon, U. S. A.," appeared in the Scandinavian journal Blyttia (24: 177–181. 1966). The author is Prof. Knut Faegri, University of Bergen, who spent a portion of the 1965 school year in residence at Oregon State University. Prof. Faegri compares the plant communities observed on Steens Mounatin with corresponding ones in the mountains of northern Europe, and outlines his ideas on the major climatic factors affecting alpine plant distributions. Because this journal may not be readily available to botanists in western North America, reprints will be provided on request by the author (Botanisk Museum, Postboks, 2637, Bergen, Norway).—Kenton L. Chambers, Botany Department, Oregon State University, Corvallis.